

FEMA Remote Sensing Innovation Workshop

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ORNL is managed by UT-Battelle, LLC for the US Department of Energy



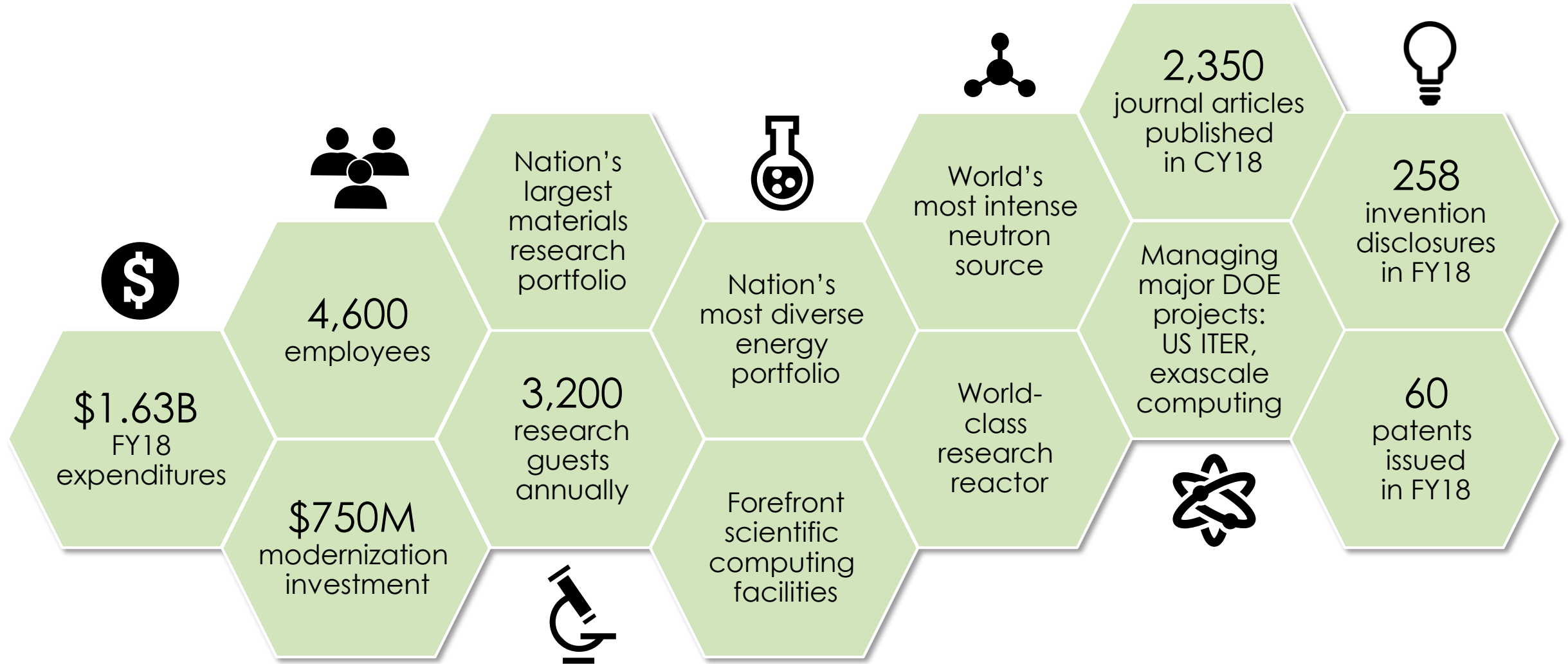
U.S. DEPARTMENT OF
ENERGY

Overview

- Introduction
- Image Quality
- UAS: MAVNet and Civil Air Patrol
- Debris Estimation
- Building Extraction
- Settlement Mapping
- URBAN-NET
- Concluding Remarks



ORNL is a leading science and energy laboratory



ORNL's mission

Deliver scientific discoveries and technical breakthroughs needed to realize solutions in energy and national security and provide economic benefit to the nation

Signature strengths

Computational science and engineering

Materials science and engineering

Neutron science and technology

Nuclear science and engineering

Commercial Image Processing Chains

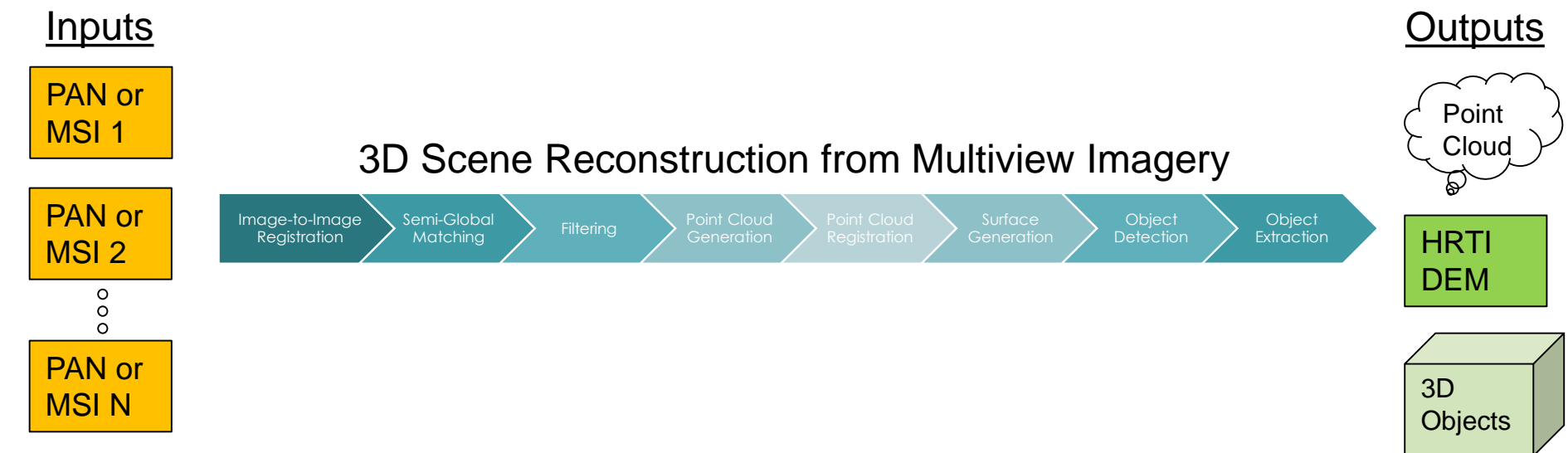
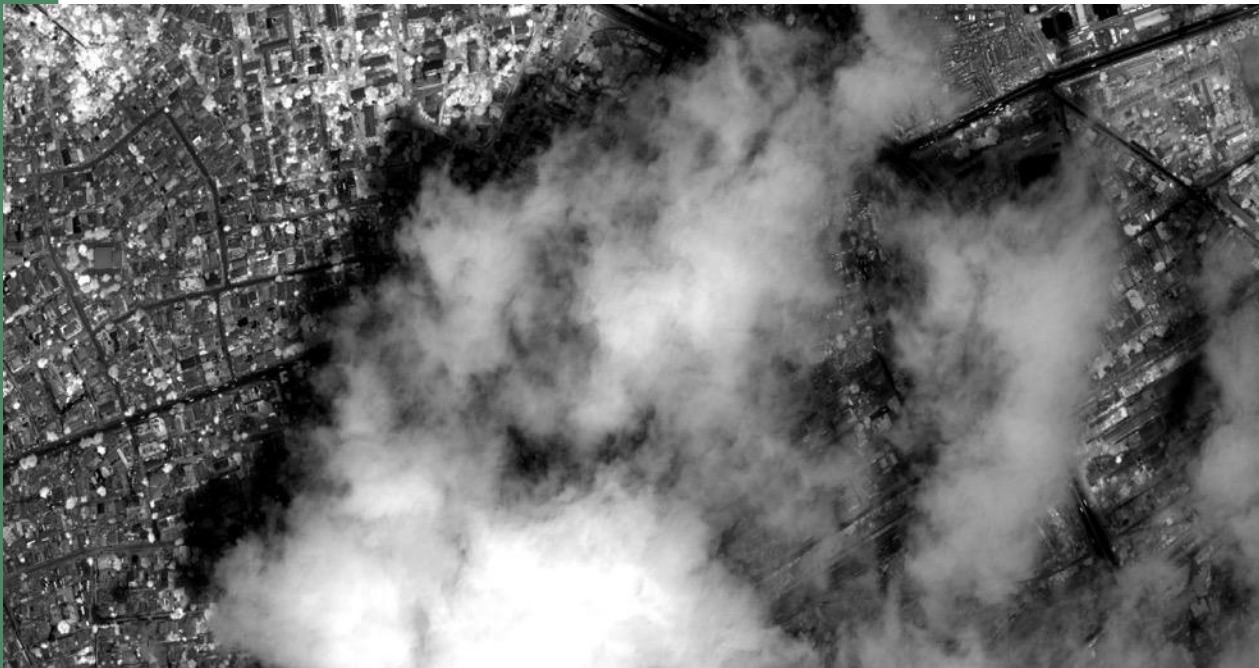
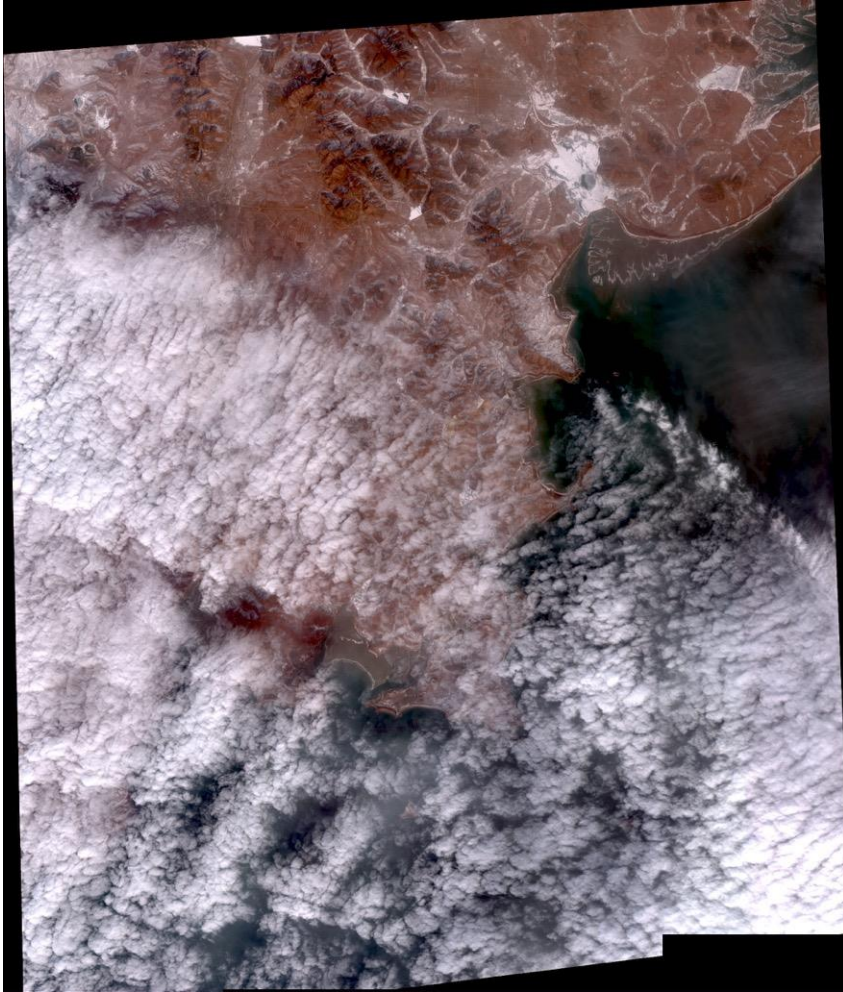


Image Quality: Cloud Detection through Machine Learning

An automated, deployed GPU-enabled application leveraging CNNs.

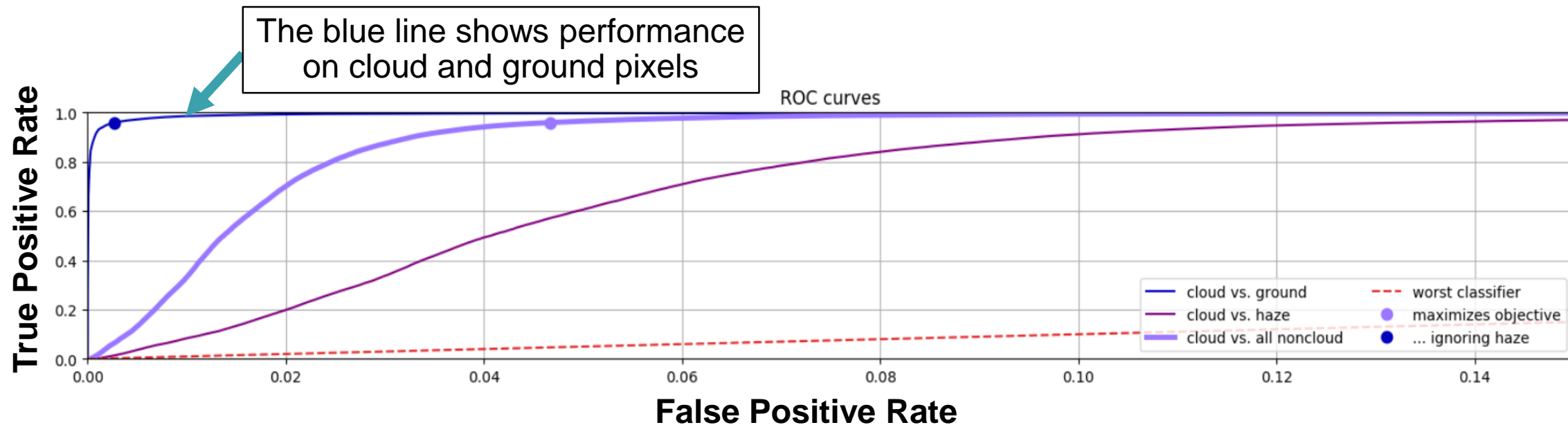
Produces a cloud percentage and 0/1 cloud mask per image based on a single-band near-IR input





- Example of cloud detection running over a complex environment with snow/ice, coastal, and sparse clouds.
- Demonstrated scalability: 84K satellite images

ROC analysis

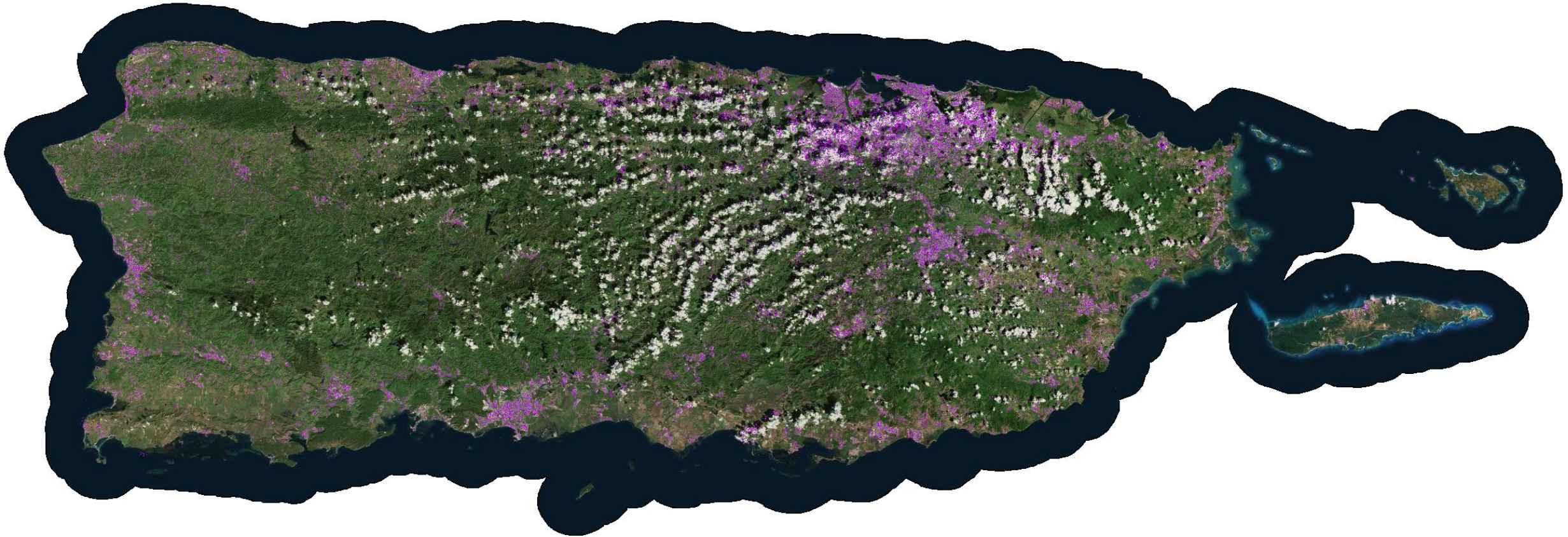


Receiver Operating Characteristic (ROC) analysis shows the performance of the model at many possible thresholds.

Examples of performance for discriminating **cloud** versus **ground** pixels (**ignoring haze** pixels), at various thresholds:

- 96.3% TP, 0.43% FP
- 98.4% TP, 1.2% FP
- 99.0% TP, 2.0% FP

Hurricane Maria: Puerto Rico



Cloudy Image



Building extraction with clouds



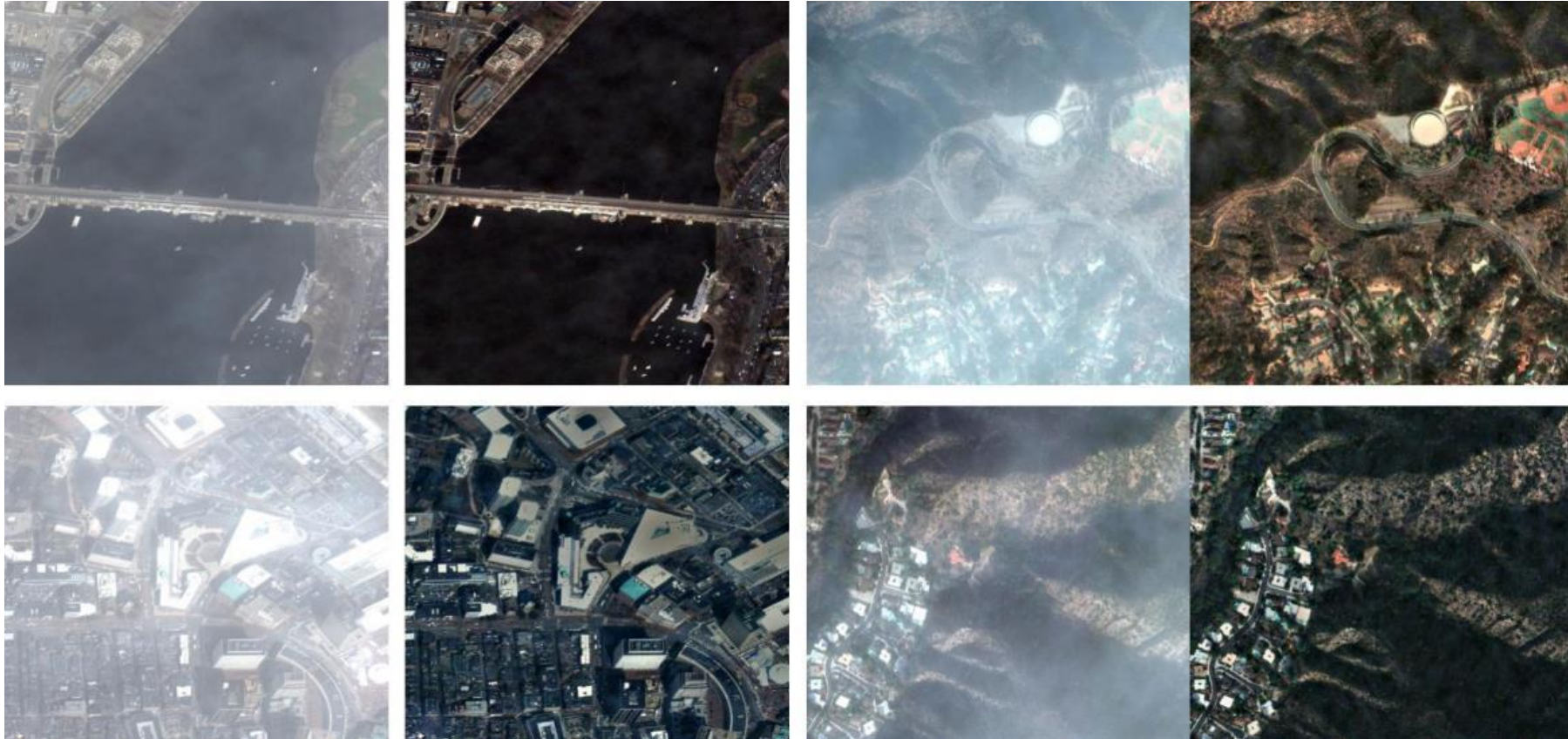
Cloud region filled with previous data



Final complete building extraction



Image Quality: DeHaze



Haze images

Corrected

Haze images

Corrected

Civil Air Patrol – Data Solution

- July 2019: ORNL visited with CAP leadership at Camp Atterbury, IN to discuss solutions for secure data management
- Developed Statement of Work to achieve the following:
 - Organize and manage the entire CAP fleet of 1,500+ unmanned aircraft from a centralized web server, enabling a “whole-picture” view of all on-going operations across the globe
 - Enable the creation and assignment of autonomous missions for field units while still retaining local control capabilities
 - Create an easy-to-use, secure, and reliable method of transferring UAS video and imagery in near-real-time to a cloud server for further processing, evaluation, and dissemination
 - Support scalable applications that may be used in conjunction with other agencies and NGOs
 - Provide secure communications solution for DJI equipment that meets DoD cyber vulnerability assessment requirements necessary for CAP adoption.

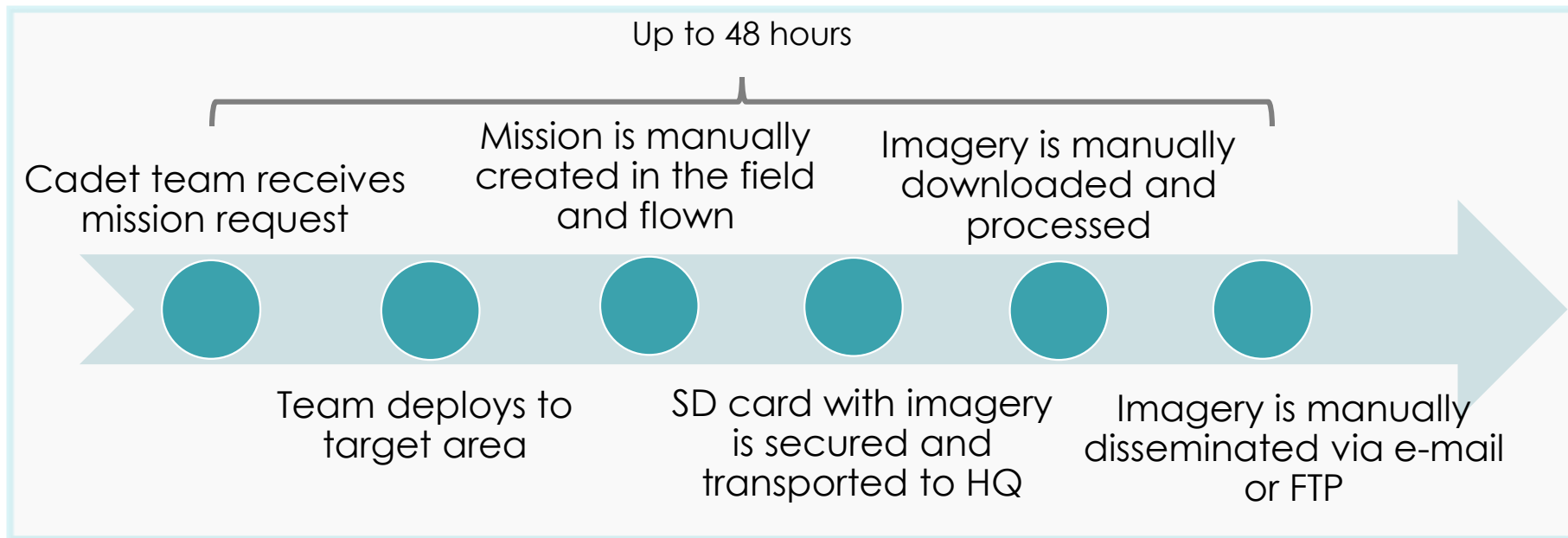


Civil Air Patrol – Data Challenge

- 1,500+ Small Unmanned Aircraft
- 75% COTS/25% Custom SAR platforms
- Hurricane Harvey
 - 8,000 images collected (~400GB)
 - 1 image utilized for decision making

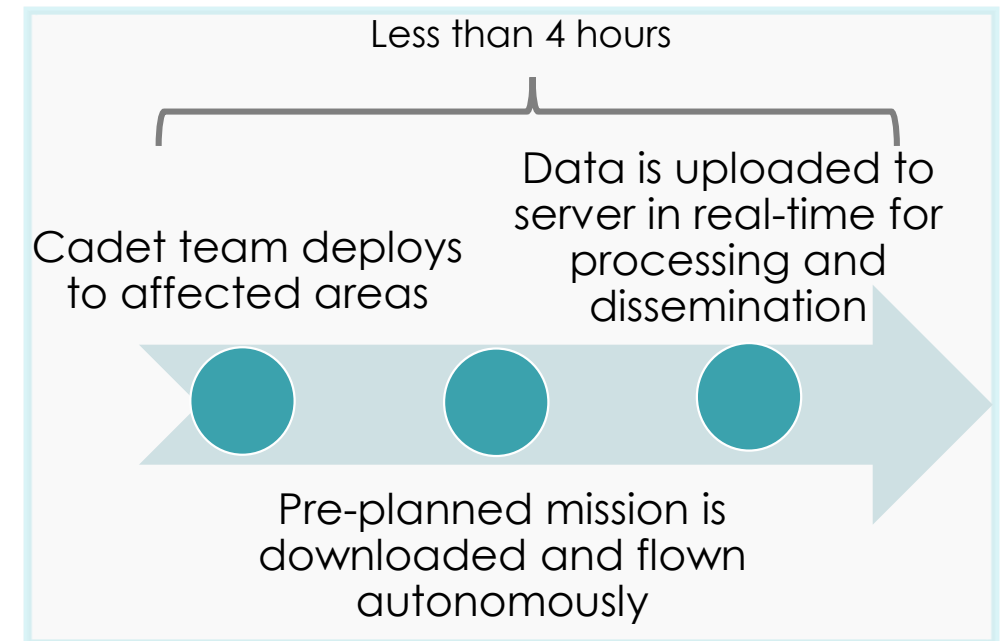
“Effective data management remains a bottleneck for the majority of public safety UAS programs.”

*- Dr. Gregory Cutsinger,
Scholar Farms*



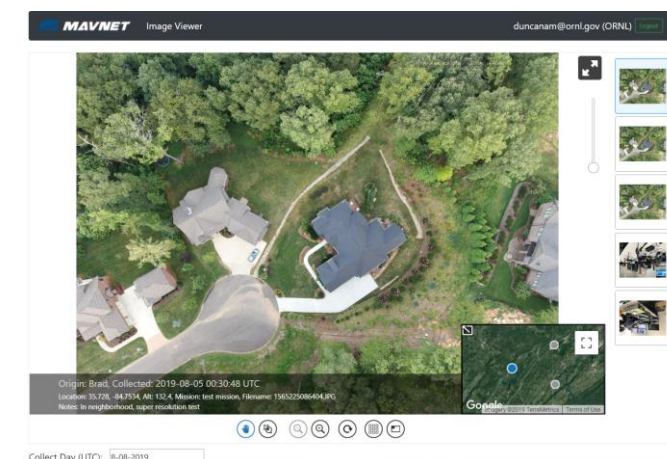
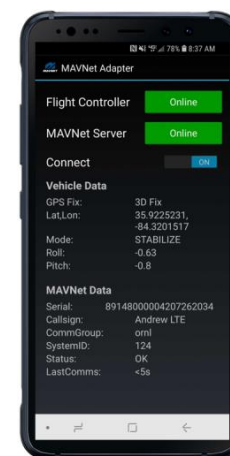
Multi-modal Autonomous Vehicle Network (MAVNet)

- Secure mobile application for Web-based UAS Operations
 - Up to 250 simultaneous aircraft and users per group (unlimited number of groups)
 - Data is immediately accessible from any web browser and available for cloud processing
 - Secured with HTTPS and AES-256 encryption, user authentication tools, and administrative permissions
 - Mobile application is easily scalable as no additional hardware is required
 - Pilot retains local control of the aircraft; satisfies FAA requirements for operation under Part 107 and/or COAs
 - Dynamic no-fly zones can be managed at the HQ level to ensure adherence to policy



MAVNet Web-Based Ground Control System

- Current system:
 - Compatible with popular web browsers
 - Globally accessible
 - Live video streaming to multiple users
 - Live command and control
 - User authentication
 - Operator permissions controlled at an administrative level
 - Overlays for live weather, ads-b manned aircraft traffic system, etc.
- Development work with FEMA/CAP:
 - Airspace management with dynamic no-fly zones
 - Real-time data pipeline for imagery, video, & telemetry
 - Autonomous Mission Planning
 - Compatibility with DJI brand equipment



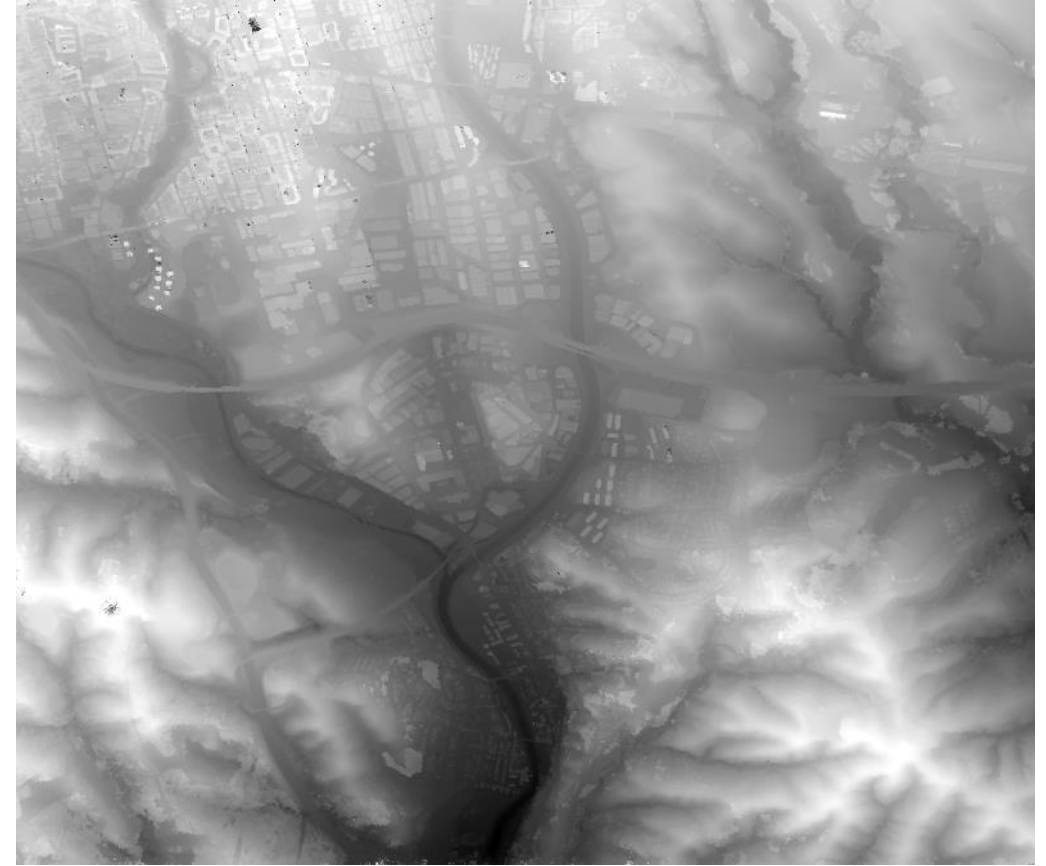
Debris Estimation: Terrain Extraction at Resolution of Input Imagery

Input Stereo Pair



Animation: Alternating Left-Right Stereo Pair

Output 3D DSM



Digital Surface Map (DSM) – Whiter = Higher

Digital Globe Left Image



Digital Globe Right Image



SRTM2 – 30m Resolution



Generated Elevation Product – 1.5m



Generated Elevation Product – 1.5m

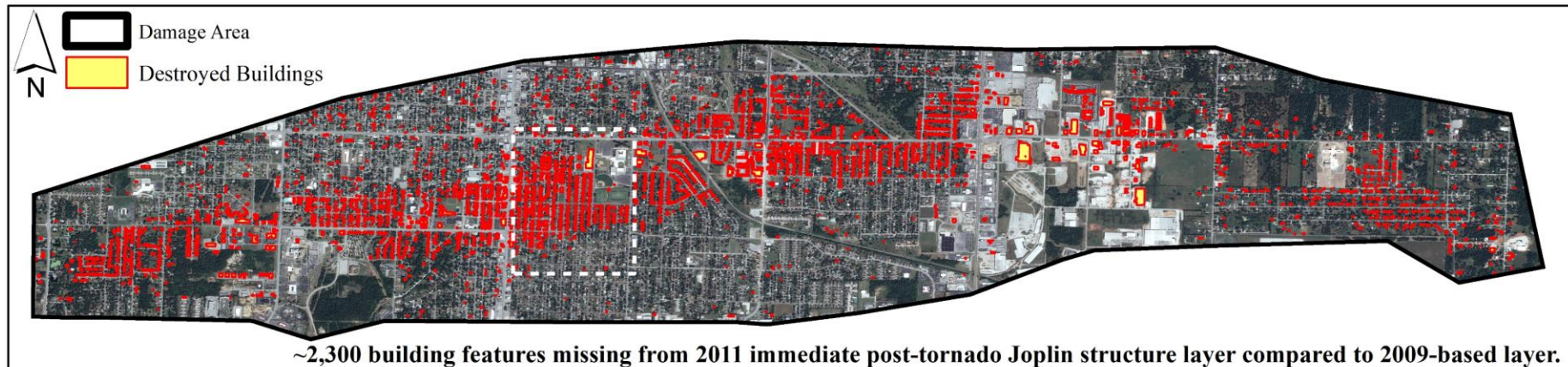


Generated Elevation Product – 1.5m



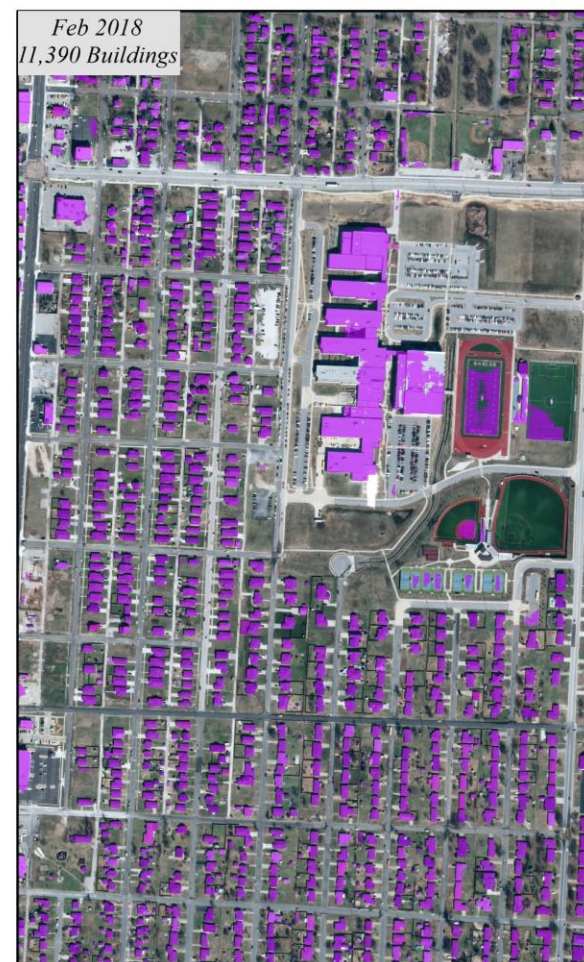


Joplin

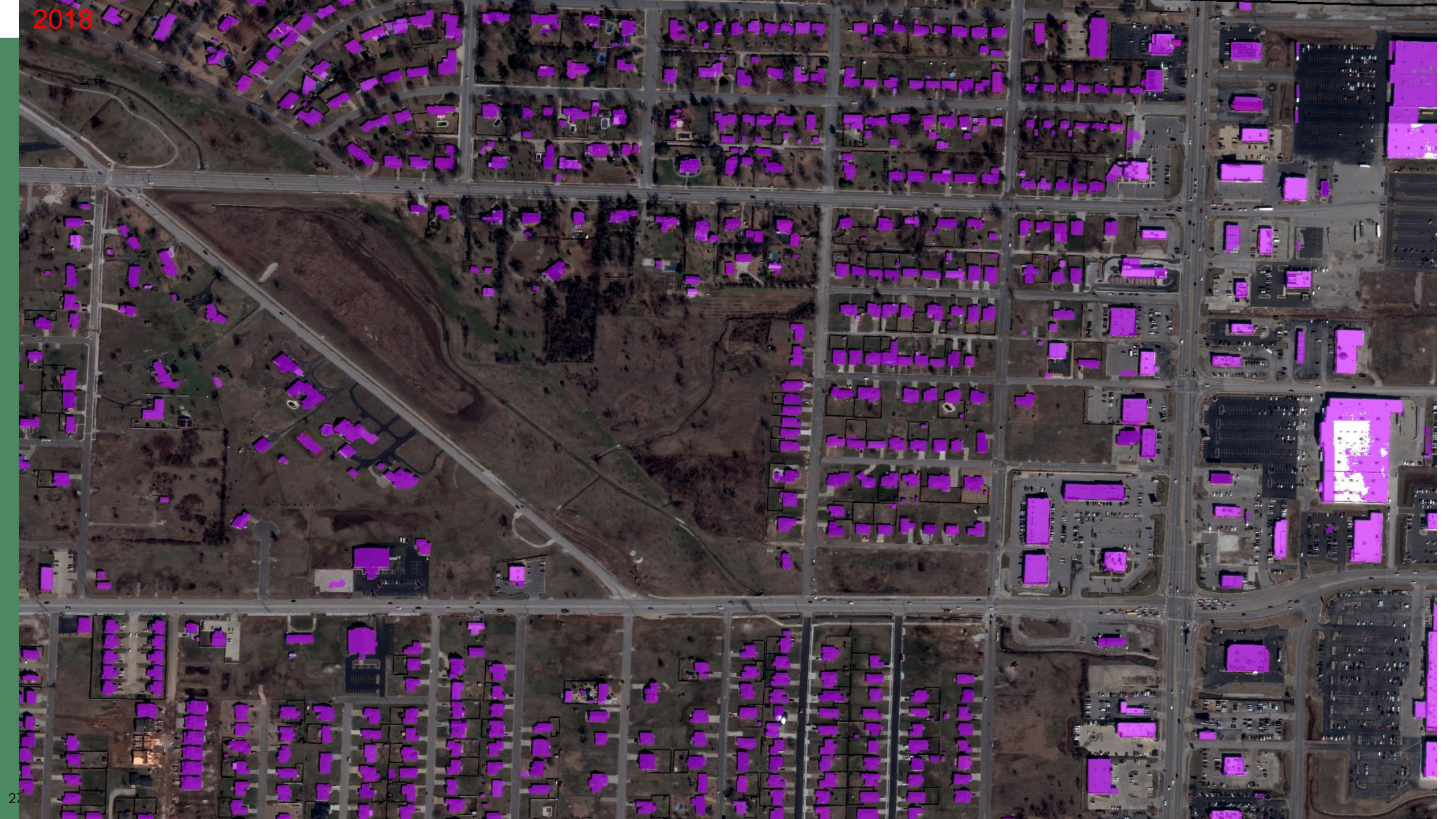


~2,300 building features missing from 2011 immediate post-tornado Joplin structure layer compared to 2009-based layer.

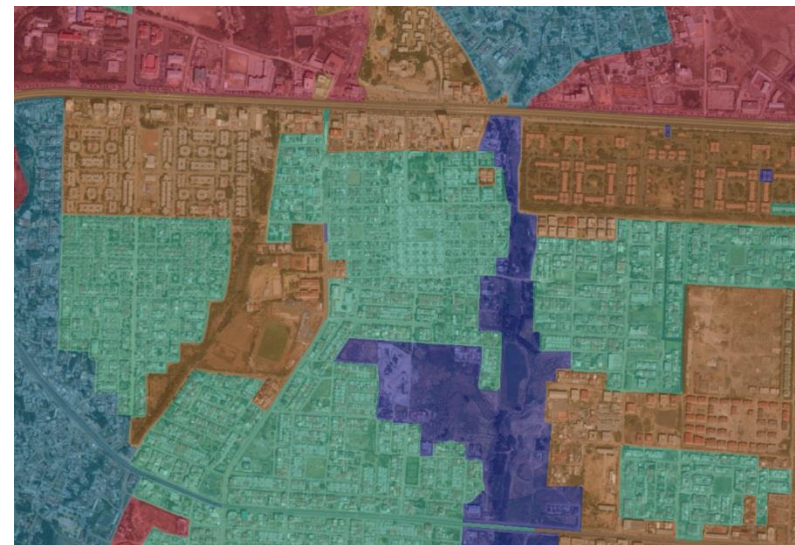
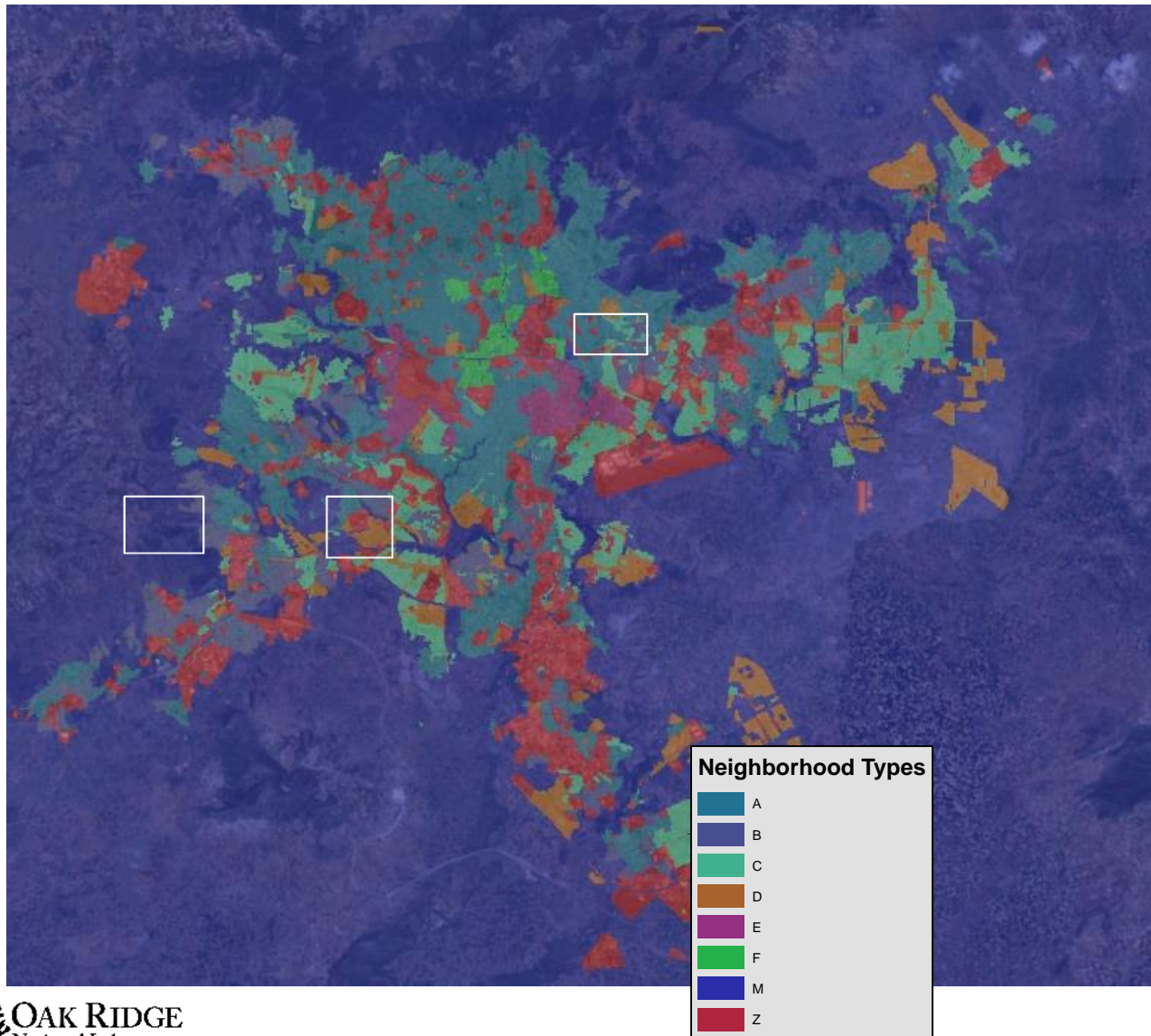
- ORNL's CNN model consistently omitted buildings that were completely destroyed by the Joplin tornado.
- This allowed us to quickly estimate the number of building features that were destroyed as well as their location.
- Requirements for a similar type of damage assessment: pre- and post-disaster imagery and a representative model



2018



Informal Construction Mapping Addis Ababa, Ethiopia



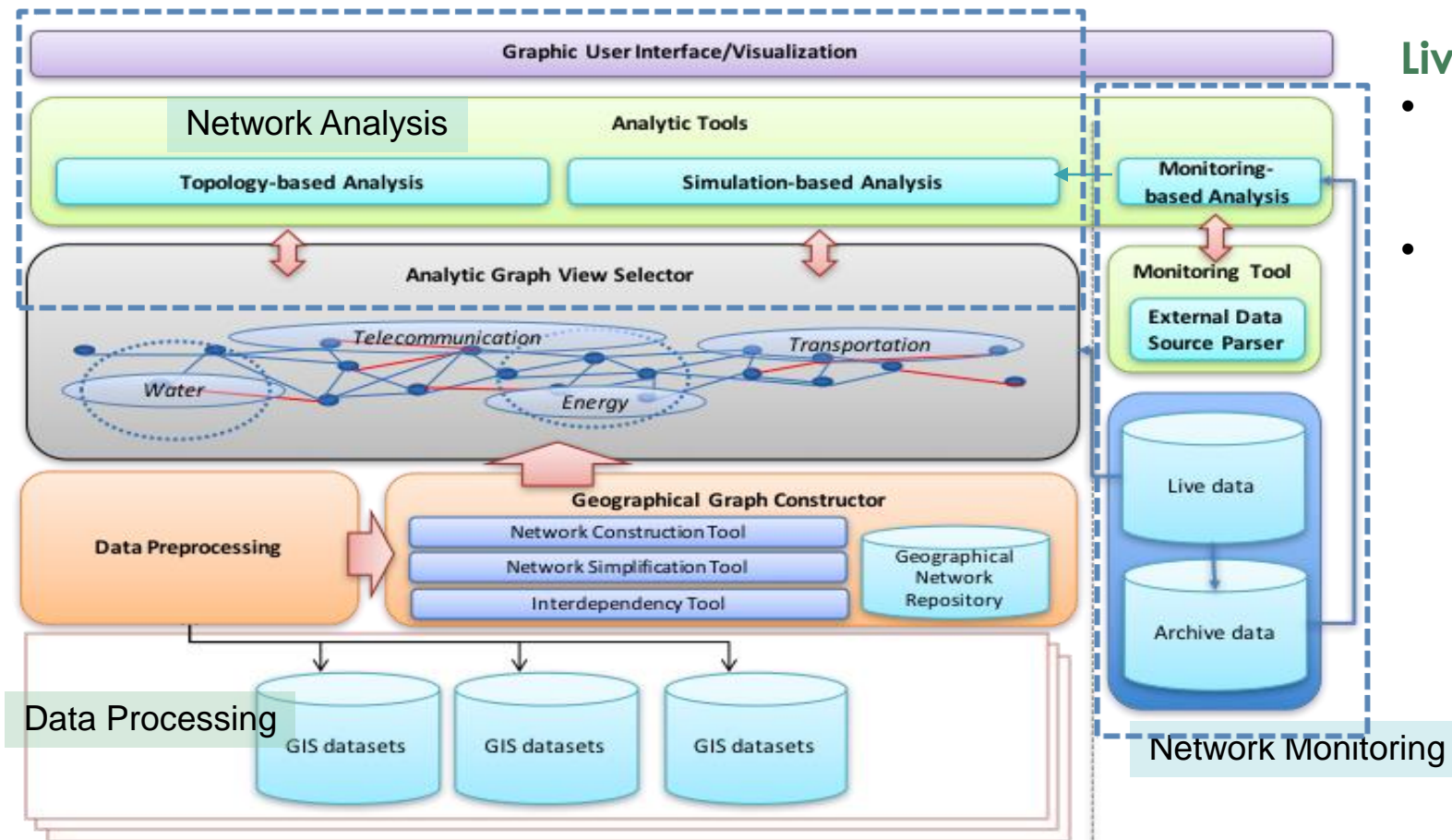
URBAN-NET System Architecture

Objective: To build a decision-support system (URBAN-NET) which aims to help subject matter experts to understand and mitigate vulnerabilities of CIs using graph-based analytics.

Core Capabilities

Identifying existing vulnerabilities in CIs

Predicting of potential propagating impacts under certain scenarios



Live data:

- Eagle-I (real time power outage monitoring)
- Data layers from post-event remote sensing imagery

Concluding Remarks

ORNL is postured to provide scalable, deployable solutions over the spectrum of the FEMA processing chain:

- 1) Pre-processing: Automated cloud removal, Dehaze
- 2) Building Extraction, Debris Estimation, and Settlement Mapping
- 3) UAS Comms and Data management
- 4) URBAN-NET

Discussion

